Designation: ~~D2395 – 07a$^{\varepsilon 1}$~~ D2395 – 14

Standard Test Methods for Density and Specific Gravity (Relative Density) of Wood and Wood-Based Materials[1]

This standard is issued under the fixed designation D2395; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

~~ε[1] NOTE—Editorial corrections were made throughout in October 2008.~~

1. Scope

1.1 These test methods cover the determination of the density and specific gravity (relative density) of wood and wood-based materials to generally desired degrees of accuracy and for specimens of different sizes, shapes, and moisture content conditions. The method title is indicative of the procedures used or the specific area of use.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D9 Terminology Relating to Wood and Wood-Based Products

D2555 Practice for Establishing Clear Wood Strength Values

D4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Base Materials

D5456 Specification for Evaluation of Structural Composite Lumber Products

~~D4444~~D7438 ~~Test Method for Laboratory Standardization and Calibration~~Practice for Field Calibration and Application of Hand-Held Moisture Meters

E1547 Terminology Relating to Industrial and Specialty Chemicals

2.2 *Other Standards:*

CAN/CSA O86 Engineering Design in Wood[3]

~~ANSI/AF&PA~~ANSI/AWC National Design Specification for Wood Construction[4]

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[1] These test methods are under the jurisdiction of ASTM Committee D07 on Wood and are the direct responsibility of Subcommittee D07.01 on Fundamental Test Methods and Properties.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from ~~Canadian Standards Association (CSA),~~ CSA Group, 5060 Spectrum Way, Mississauga, ON L4W 5N6, Canada, http://www.csa.ca.

[4] Available from American ~~Forest and Paper Association (AF&PA), 1111 19th St., NW, Suite 800, Washington, DC 20036, http://www.afandpa.org.~~Wood Council (AWC) 222 Catoctin Circle, SE, Suite 201 Leesburg, VA 20175, www.awc.org.

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this standard, refer to Terminology D9.

3.2 ~~*Definitions:*~~*Definitions of Terms Specific to This Standard:*

3.2.1 *density,* ρ [kg/m^3, g/cm^3 or lb/ft^3],*n*—the mass of a unit volume of a specimen at specified moisture content.

NOTE 1—The moisture content is specified for both mass and volume. For further discussion, see Appendix X3.

3.2.1.1 *density at moisture content M*—density based on the mass of a specimen including moisture and its volume at the same moisture content.

NOTE 2—The mass and volume at 12 % moisture content are frequently used.

3.2.1.2 *density, basic or conventional,* ρ_b—density based on the oven-dry mass of a specimen and its green volume.

3.2.1.3 *density, oven-dry or in the absolute dry condition,* ρ_0—density based on the oven-dry mass of a specimen and its oven-dry volume.

3.2.2 *green volume, n*—the ~~solid~~ volume of wood ~~volume~~specimen before any shrinkage occurs due to drying to moisture content below the fiber saturation point (about 30 %).

NOTE 3—Green volume may also be obtained by water soaking of partially dry wood specimens until they reach fully swollen condition above the fiber saturation point (e.g., see 12.2.3.1). See Appendix X3. The fiber saturation point of wood averages approximately 30% moisture content, but in individual species and individual pieces of wood it can vary by several percentage points from that value.

3.2.3 *moisture content, ~~n—~~M [%]*—the amount of water contained in ~~wood,~~ a specimen, expressed as a percentage of ~~the mass of oven-dry wood.~~its oven-dry mass.

~~3.1.2.1 *Discussion—*~~

~~In general, the amount of water in wood can be expressed on two different bases: as a percentage of the mass of oven-dry wood, or a percentage of the total mass of wood and water. To avoid misunderstandings, it must be clear which basis is being used. In the forest industry and the wood products industry, the moisture content is usually expressed as a percentage of the mass of oven-dry wood.~~

3.2.4 *specific ~~gravity,~~ gravity (relative density), S, n*—the ratio of the oven-dry mass of a specimen to the mass of a volume of water equal to the volume of the specimen at a specified moisture content.

~~3.1.3.1 *Discussion—*~~

~~As both the mass and volume of wood vary with the amount of moisture contained in the wood, specific gravity as applied to wood is an indefinite quantity unless the conditions under which it is determined are clearly specified. The specific gravity of wood is based on the oven-dry mass, but the volume may be that in the oven-dry, partially dry, or green condition. For further discussion, see Appendix X2.~~

NOTE 4—The volume may be that in the oven-dry, partially dry, or green (fully swollen) condition. Further in this standard, the terms specific gravity and relative density are used interchangeably. For further discussion, see Appendix X3.

3.2.4.1 *specific gravity at ~~M %~~ moisture ~~content,~~ content M, n*—specific gravity based on the oven-dry mass of ~~wood~~ a specimen and its volume at a specified moisture content between the oven-dry condition and the fiber saturation ~~point (volume at 12 % moisture content is frequently used).~~ point.

NOTE 5—The volume at 12 % moisture content is frequently used.

3.2.4.2 *specific gravity, ~~basic,~~ basic (or green), S_b, n*—specific gravity based on the oven-dry mass of ~~wood~~ a specimen and its green volume.

3.2.4.3 *specific gravity, oven-dry or on oven-dry basis, S_0, n*—specific gravity based on the oven-dry mass of ~~wood~~ a specimen and its oven-dry volume.

4. Summary of Test Methods

4.1 The ~~accuracy of the specific gravity value~~ precision of test results obtained on a representative specimen ~~will depend~~ depends upon the ~~accuracy~~precision of the measurements made. ~~If~~ Method A is used for precise measurements when the specimens are carefully prepared and regular in ~~shape, the volume determined by Test Method A can be quite exact. The volume of irregularly shaped specimens can best be determined by immersion in water~~ shape. Method B is used for precise measurements if the specimens are irregularly shaped and if due care is taken to prevent ~~absorption~~sorption of ~~water, Test Method B will give results of great precision. Test Method~~ water. Test Method C is an approximate method ~~but a procedure that can be very useful, particularly~~ that is permitted for use as part of a production ~~procedure.~~ procedure or in other situations where less precision is acceptable. Test

Methods D and E are especially adapted to density or specific gravity measurements of living trees or of in-place elements, and the ~~accuracy~~precision of the result is dependent upon the care used in obtaining the specimen. Test Method F is a specific procedure for wood chips.

5. Significance and Use

5.1 Density and specific gravity are cornerstone terms that help define many useful properties of wood and wood-based products. These terms designate concepts that have distinct definitions though they relate to the same characteristic (mass in a unit volume). Generally, in the US and Canada, density of wood is measured in terms of *specific gravity*, or *relative density*. In the wood-based composites industry and internationally the term density is often preferred.

5.2 The *basic density* and *basic specific gravity* of wood ~~gives an excellent measure of the amount of wood substance present in a sample. Thus, it may serve as a valuable~~ are used in the forestry industry for calculating the oven-dry weight of wood fiber contained in a known wood volume of various wood species. Thus, it serves as an indicator of the amount of wood pulp that could be produced, the workability of the ~~material, or the strength characteristics of a specimen or a species. It should be recognized~~material or its shipping weight. This information is referenced in various resources, including Wood Handbook.[5] Note that specific gravity varies ~~between trees,~~ within a tree, between trees, and between species. Since the specific gravity of wood cell wall substance is practically constant for all species (approximately 1.53), it is apparent that individual specific gravity ~~values are~~value is indicative of the amount of wood cell wall substance present. It affords a rapid and valuable method for selection of wood for specific uses. In US and Canadian building codes, the *oven-dry specific gravity* is correlated to various strength characteristics of wood products (e.g., compression perpendicular to grain, shear strength and fastener holding capacity).

5.3 It ~~may be~~is often desirable to know the density or specific gravity of a living tree, a structural member already in place, a log cross section, a segment of a research element, or the earlywood or latewood layer. ~~The specimen thus may~~ Therefore, it is possible that specimens will be large or small, regular or ~~irregular,~~ irregular in shape, and at a variety of moisture contents. These test methods give procedures that include all of these variables and provides for calculation of density and specific gravity values to degrees of ~~accuracy~~precision generally needed.

5.4 In the wood-based composites industry, the product density or specific gravity also provides an important indicator of potential product attributes. For wood-based materials, the same test methods are used; however, the measurements typically combine the mass from the wood substance with any resin, wax, or other solid additives present in the material. These properties are not to be confused with *equivalent specific gravity* of structural composite lumber used to characterize its fastener-holding capacity determined in accordance with D5456.

6. Test Specimens

6.1 The ~~specific gravity~~ test specimens shall be fully representative of the material from which they are taken. The specimen size shall be such that accurate measurements of mass and volume are easy to attain. Where other standards specify the location and size of ~~specific gravity~~ test specimens, these requirements shall be carefully followed. The specimens shall be carefully cut from the larger element to ensure clean-cut surfaces. All loose fibers shall be carefully removed before the specimen is weighed and measured. The specimen shall be free from knots, and if pitch or other infiltrates are present, this shall be noted in the report or they shall be extracted before ~~specific gravity values are obtained.~~taking measurements and weighing.

6.2 *Measurements*—The dimensions of test specimens shall be measured to a precision of ±0.3 % or less, and the mass shall be determined to a precision of ±0.2 % or less. Where drying of specimens is required, this shall be done in ~~an oven~~ a forced convection oven that can be maintained at 103 ± ~~2°C. (For most panel materials and wood specimens 1 in. (25 mm) in length parallel to grain, drying for 48 h in an oven~~2°C throughout the drying chamber for the time required to dry the specimen to reach practical equilibrium (see Note 6~~having good air circulation and exchange will be sufficient to reach constant mass.)~~). The oven shall be vented to allow the evaporated moisture to escape.

NOTE 6—For most specimens of wood, wood structural panels and structural composite lumber 1 in. (25 mm) in length parallel to grain, drying for 24 h in an oven having good air circulation and exchange will be sufficient to reach practical equilibrium (no more than 0.2% mass change over 8 h period of drying). For other wood-based materials, the drying time should be established by test. For further discussion, see Appendix X3.

7. ~~TEST METHOD A~~Test Method A—Volume~~—VOLUME BY MEASUREMENT~~ by Measurement

7.1 *Applicability:*

7.1.1 ~~*Shape of Specimen*—The specimen must~~This procedure is adaptable to any size of specimen at any moisture content. The specimen shall be regular in shape with right-angle corners for determination of volume by lineal measurement. ~~The procedure is adaptable to any size of specimen or to specimens of any moisture content.~~ If the surfaces of the specimen are smooth and sufficient measurements are taken, the volume can be obtained with ~~considerable accuracy.~~high precision. Special care ~~must~~shall be taken in measurement of very small or thin specimens. Volume of irregular or rough-surfaced specimens ~~should~~shall be obtained by Test Method B.

[5] Forest Products Laboratory General Technical Report FPL-GTR-190, *Wood Handbook: Wood as Engineering Material*, Forest Products Society, 2010.

7.2 *Procedures:*

7.2.1 ~~*Measurement—*~~*Volume—*Measure the ~~length (~~length, width,~~L), width (w),~~ and thickness ~~(t)~~ of the specimen in accordance with 6.2 in a sufficient number of places to ensure ~~an accurate~~a precise indication of volume. ~~In small specimens, uniform in size, one or two measurements of each dimension will suffice; in larger specimens the number of measurements will depend on the uniformity of the specimen, but at least three measurements of each dimension will be required.~~

7.2.2 ~~*Mass—*~~*Initial mass, (m_M)—*Determine the initial mass ~~(m_M)~~ of the specimen at the time of test in accordance with 6.2.

7.2.3 ~~*Moisture Content—*~~*Oven-dry mass (m_0)—*~~Determine the moisture content (~~Oven-dry mass ~~M)~~ of the specimen ~~to permit description of the basis on~~shall be determined by drying to practical equilibrium in accordance with 6.2 ~~which the specific gravity~~or by calculation (13.1.2 ~~is computed. Test Methods~~) in special situations (7.2.4.4~~D4442 and~~).~~D4444 indicate procedures that should be used.~~

~~7.2.4 *Small Specimens—*The entire specimen may be used for determination of moisture content.~~

7.2.4 ~~*Intermediate Specimens—*~~*Moisture Content—*~~When the specimen is of a size that is unsuitable for moisture content determinations~~Determine the moisture content (*M* ~~(the time to oven-dry to constant mass would be excessive), a segment may be cut from the specimen for a moisture content specimen. Select this segment so that its moisture content is representative of that of the larger specimen. Where possible in solid wood elements, the moisture content specimen shall be of full cross-sectional dimensions and 1 in. (25 mm) in length (parallel to grain). In sheet materials the specimen shall be equal in thickness to the thickness of the material~~) of the specimen to permit description of the basis on which the density or specific gravity is computed. Test Methods D4442 and ~~3~~D7438 ~~by 6 in. (76 by 122 mm) in size.~~indicate procedures that shall be used.

7.2.4.1 *Small Specimens*—The entire specimen shall be used for determination of moisture content in accordance with D4442.

7.2.4.2 *Intermediate Specimens*—When the specimen is of a size that is unsuitable for moisture content determinations (the time to oven-dry to constant mass would be excessive), a segment shall be cut from the specimen in accordance with 6.1 for moisture content measurement using methods D4442. Select this segment so that its moisture content is representative of that of the larger specimen. Where possible in wood elements and structural composite lumber, the moisture content specimen shall be of full cross-sectional dimensions approximately 1 in. (25 mm) in length (parallel to grain). In sheet materials the specimen shall be equal in thickness to the thickness of the material and 3 by 6 in. (76 by 122 mm) in size.

7.2.4.3 *Structural Elements*—In full-size members, the moisture content shall be determined on a segment cut from the member in accordance with 6.1. It shall be of full cross-sectional dimensions and approximately 1 in. (25 mm) in length parallel to grain, and shall be selected from a representative area of the member (see Note 7).

NOTE 7—The specimens should be cut in the area of interest. Where possible, avoid the effects of end drying.

7.2.4.4 *Special Situations*—Where the specimen or element cannot be cut to secure a moisture content segment, an approximate moisture content shall be obtained through the use of a moisture meter in accordance with Test Methods D7438 (see Note 8). The use of moisture meters shall not be permitted for materials other than wood.

NOTE 8—Since the moisture content value obtained with moisture meter is approximate, it should be recognized that the specific gravity values obtained are approximate.

~~7.2.6 *Structural Elements—*In full-sized members, determine the moisture content from a segment cut from the member. It shall be of full cross-sectional dimensions and 1 in. (25 mm) in length (parallel to grain), and shall be selected from a representative area of the member. To avoid the effects of end drying, cut the specimen at least 18 in. (457 mm) in from the end of the member.~~

~~7.2.7 *Special Situations—*Where the specimen or element cannot be cut to secure a moisture content segment, an approximate moisture content may be obtained through the use of a moisture meter which is used in accordance with the manufacturer's recommendations. Since the moisture content value is approximate, it should be recognized that the specific gravity value obtained will also be approximate.~~

~~7.2.8 *Specimen Preparation—*When the moisture content specimen is a portion of the element, remove all loose particles from the specimen and determine the initial mass (m_M) in accordance with 6.2.~~

~~7.3 *Drying—*Oven-dry the moisture content specimen to constant mass in accordance with 6.2, and determine the oven-dry mass (m_0).~~

8. ~~TEST METHOD B~~Test Method B—Volume~~—VOLUME BY WATER IMMERSION~~ by Water Immersion

8.1 *Applicability:*

8.1.1 ~~*Type of Specimen—*~~This procedure is particularly adaptable to specimens of irregular shape or having a rough ~~surface. Limitations on specimen size are based primarily on size of immersion tanks available. In small size specimens, less than 1 cm^3 in volume, air bubbles adhering to the specimen surface can~~surface (see Note 9~~result in considerable error in volume measurement and thus to the computed specific gravity value. Freshly cut green wood will not absorb appreciable quantities of water during the brief immersion period. As soon as any drying of the wood has taken place however, the surface must be sealed before immersion in water or else the volumetric displacement of the wood specimen will be in error in an amount equal to the volume of water absorbed by the wood.~~).

NOTE 9—Limitations on specimen size are based primarily on size of immersion tanks available. In small size specimens, less than 1 cm^3 in volume, air bubbles adhering to the specimen surface can result in considerable error in volume measurement and thus in the computed density or specific gravity

value. Freshly cut green wood will not absorb appreciable quantities of water during the brief immersion period. If any drying has taken place, the surface of the specimen needs to be sealed before immersion in water or else the volumetric displacement of the specimen will be in error in an amount equal to the volume of water absorbed by the wood.

8.2 *Procedures:*

8.2.1 ~~*Mass*—~~*Initial mass (m_M)*—Determine the initial mass ~~(m_M)~~ of the specimen at time of test in accordance with 6.2.

8.2.2 *Volume*—Determine the volume of the specimen by ~~one of the following modes. Volume may be determined in the as received condition if the specimen is green; or in the as received condition if the specimen is partially dry or after oven-drying if the pores are adequately sealed (see 8.2.2.5). Determine the volume of the specimen by~~ measuring the volume ~~of water displaced or by determining~~ or the mass of the water ~~displaced. The mass~~ displaced by the specimen using one of the following modes. The mass of water in grams is numerically equal to ~~the~~its volume in cubic ~~centimetres.~~centimeters. Unless the volume is determined on a specimen of green wood, the surfaces of the specimen shall be adequately sealed (see 8.2.2.5).

8.2.2.1 *Mode I*—Place the specimen in a tank of known volume and add sufficient water to fill the ~~tank.~~ tank with the specimen being fully submerged. Then remove the specimen and determine the volume of water remaining. The tank volume less the volume of water remaining is equal to the volume of the specimen. The relationship between specimen volume and tank volume shall be such that the precision of specimen volume measurement is ~~high.~~adequate to the purpose of the test.

8.2.2.2 *Mode II*—Place a container holding enough water to completely submerge the specimen on ~~one pan of~~ a balance as shown in Fig. 1. Then tare the balance to the combined mass of the container and ~~water with mass added to the other pan. Hold the specimen~~water. Using a sharp, pointed, slender rod, place the specimen in the container so that it is completely submerged in the water without touching the sides of the ~~container by means of a sharp, pointed, slender rod and balance the scales again. The mass added to restore~~ container. After reaching the equilibrium, the reading on the balance is equal to the mass of water displaced by the specimen. ~~Alternatively, an automatic balance may be used and will greatly facilitate the speed of such measurements. If very small specimens are used, the accuracy of resulting data is likely to be low.~~

8.2.2.3 *Mode III*—Place a container holding enough water to completely submerge the specimen ~~below one pan of~~ on a balance as shown in Fig. 2. The container shall be sufficiently large so that immersion of the specimen causes no ~~material~~significant change in water level. Suspend a wire basket of sufficient mass to ~~hold~~keep the specimen submerged ~~from this same pan~~ and immerse it in the water. ~~Balance the~~ Tare the balance to the mass of the basket when freely ~~immersed with mass added to the other scale pan.~~ immersed. Weigh the specimen in air. Place the specimen in the basket and hold it completely submerged without touching the ~~container while balancing the scales again. The mass added to restore~~container. After reaching the equilibrium, the mass reading on the balance, if the specimen is lighter than water, plus the mass of the specimen in air equals the volume of water displaced. If the specimen is heavier than water, subtract the mass ~~added to restore~~reading on the balance from the mass of the specimen in air to determine the volume of water displaced.

8.2.2.4 *Mode IV*—Immerse the specimen, of an elongated shape, in a graduated tube having a cross section only slightly larger than that of the specimen as shown in Fig. 3. Read the water level in the tube, preferably to an even graduation mark, before immersing the specimen. Immerse the specimen, hold it submerged with a slender pointed rod if necessary, and determine the water level again. The difference in water level is equal to the volume of the specimen.

8.2.2.5 *Surface Treatment of Specimen*— ~~Green specimens may be immersed in water for volume determinations without material absorption of water that will affect volume determinations. Dip air-dry~~ Partially dry or oven-dry specimens shall be dipped in hot paraffin wax before making volume ~~determinations.~~ determinations (see Note 10). After the wax dip, weigh the specimen again and use this mass in conjunction with the immersed mass for determining volume in Mode II and Mode III (8.2.2.2 and 8.2.2.3). ~~Alternatively, softwood specimens or hardwood specimens with small pores may be dipped in a solution of paraffin wax in carbon tetrachloride: 1 oz of paraffin wax in 260 in.^{3} of carbon tetrachloride (1 g of paraffin wax in 150 cm^3 of carbon tetrachloride). Before immersion, allow the carbon tetrachloride to evaporate for a few minutes. The gain in mass due to the thin film of wax deposited is negligible. This test method may be effectively used on air-dry specimens since thin wax film does not appear to affect shrinkage when the specimen is oven-dried. (Warning—Observe necessary precautions to ensure proper ventilation when carbon tetrachloride is used.)~~

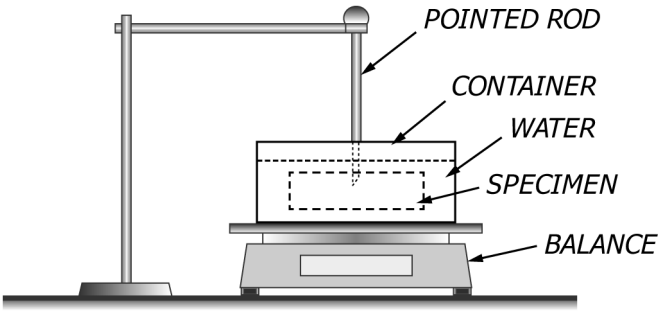

FIG. 1 Diagrammatic Sketch of Apparatus Used to Measure Volume of Specimens by Test Method ~~B-II~~B (Mode II)

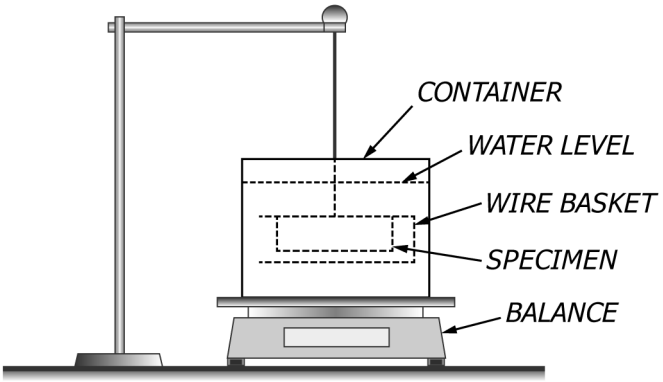

FIG. 2 Diagrammatic Sketch of Apparatus Used to Measure Volume of Specimens by Test Method ~~B-III~~B (Mode III)

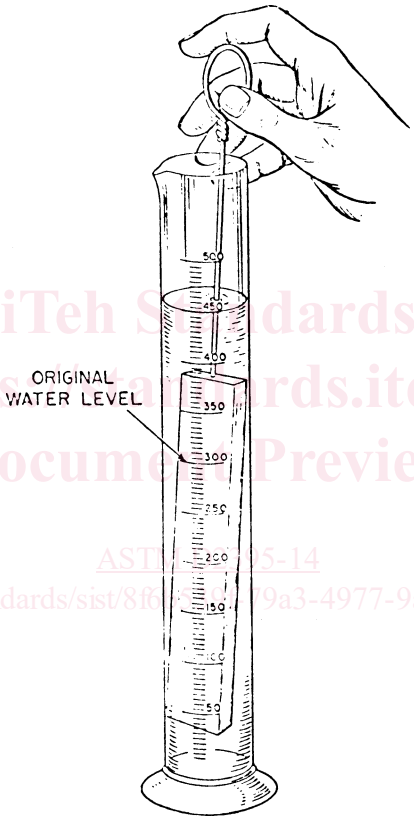

FIG. 3 ~~Test Method of~~ Measuring Volume of Elongated Specimens Using a Graduated Tube by Test Method B (Mode IV)

NOTE 10—Specimens of green wood may be briefly immersed in water without appreciable absorption that will affect volume determinations.

8.2.3 *Oven-dry mass (m_0)*—Oven-dry mass of the test specimen shall be determined by drying to practical equilibrium in accordance with 6.2.

8.2.4 *Moisture Content*—Determine the moisture content (M) of the specimen in accordance with Test Methods D4442 to permit description of the basis on which the density or specific gravity is ~~computed.~~calculated.

~~8.2.3.1 *Specimen*—The entire specimen or a representative segment may be used for the moisture content determination. Remove all loose particles from the specimen and determine the initial mass (m_M) in accordance with 6.2.~~

~~8.2.4 *Drying*—Oven-dry the moisture content specimen to constant mass in accordance with 6.2 and determine the oven-dry mass (m_0).~~

9. ~~TEST METHOD C~~Test Method C—Flotation~~—FLOTATION TUBE~~ Tube

9.1 *Applicability:*

9.1.1 ~~*Type of Specimen*—~~This procedure provides a rapid means for obtaining an approximate density or specific gravity for an elongated specimen of uniform cross section and known moisture ~~content.~~content (see Note 11).